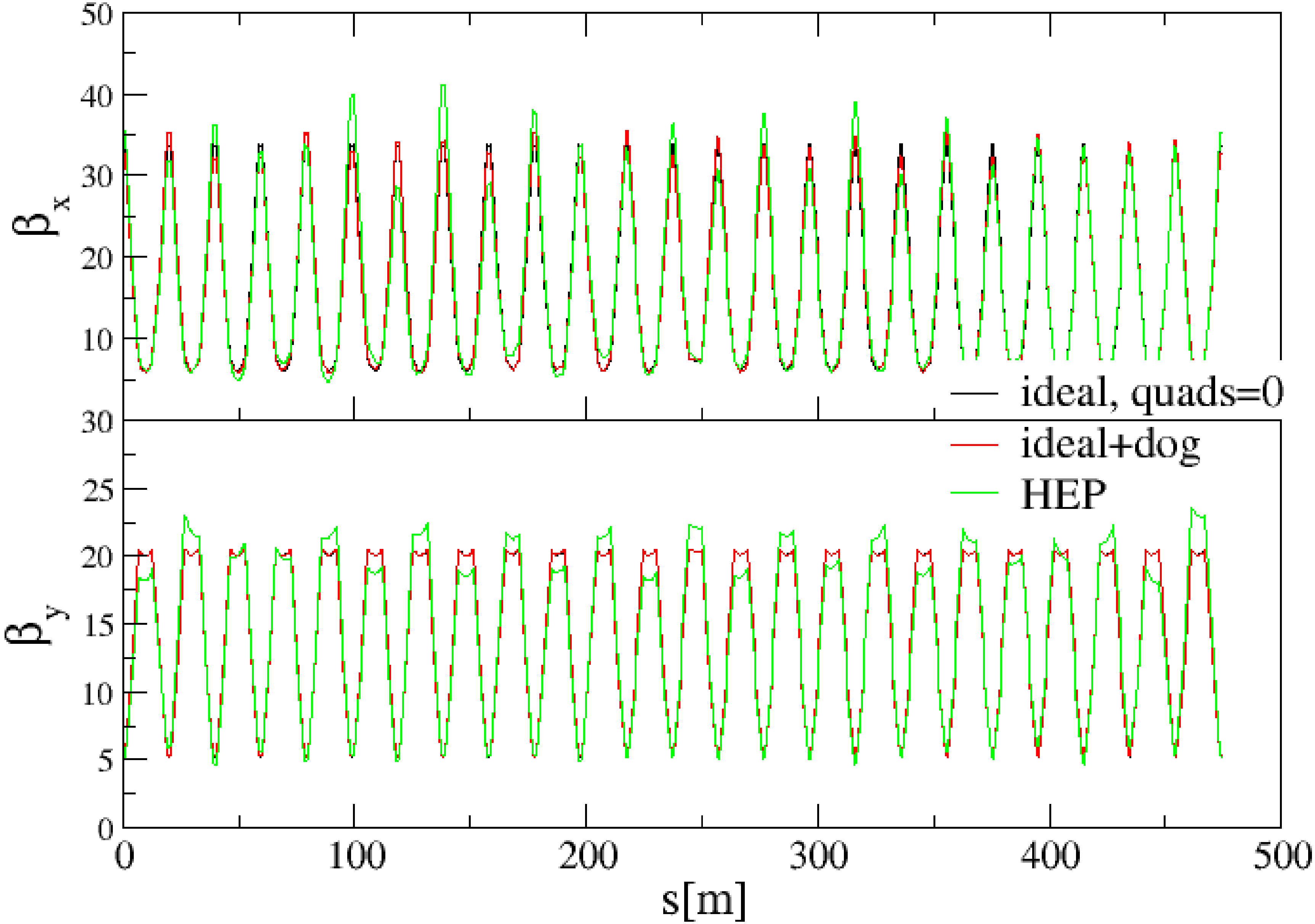
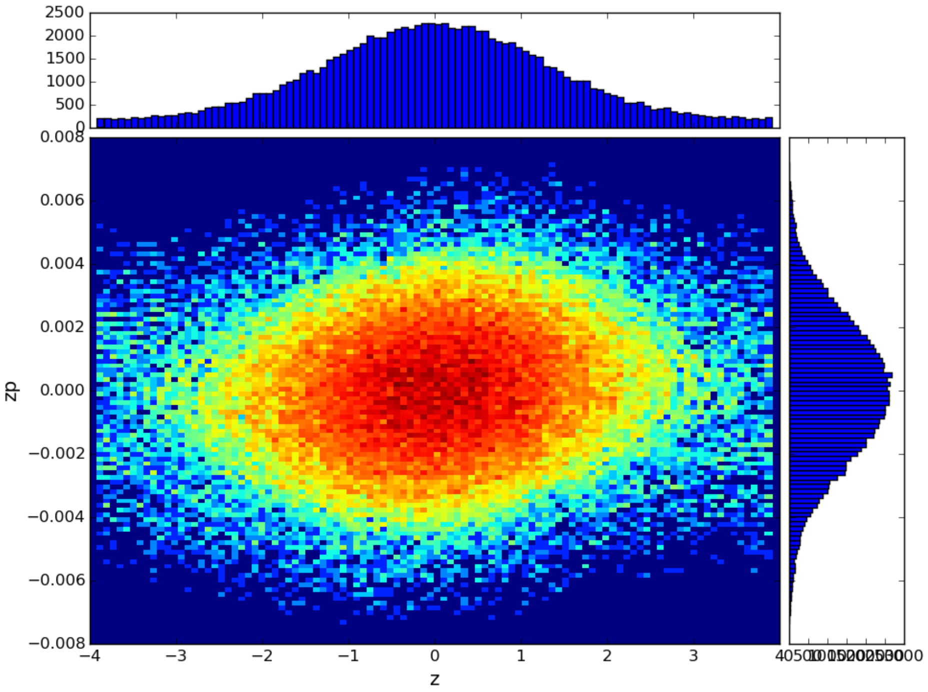
Synergia simulations of Booster beams



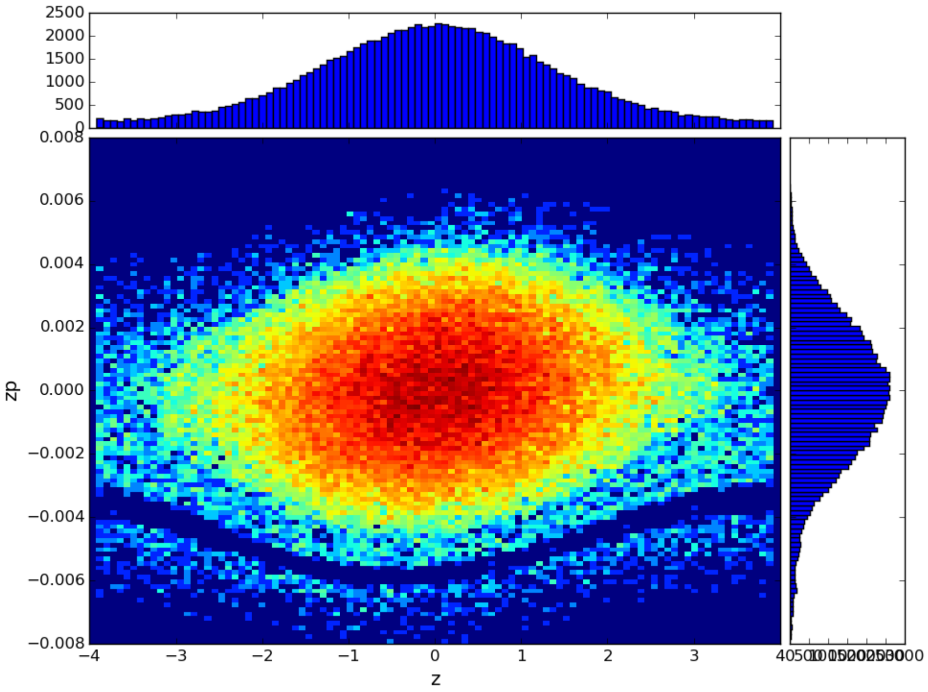
50
40
30
20
10
30
25
20
15
10
5
0
0
100
200
300
400
500
β_x
β_y
s[m]
ideal, quads=0
ideal+dog
HEP

Loss is dependent on the input beam distribution

turn 100



turn 500

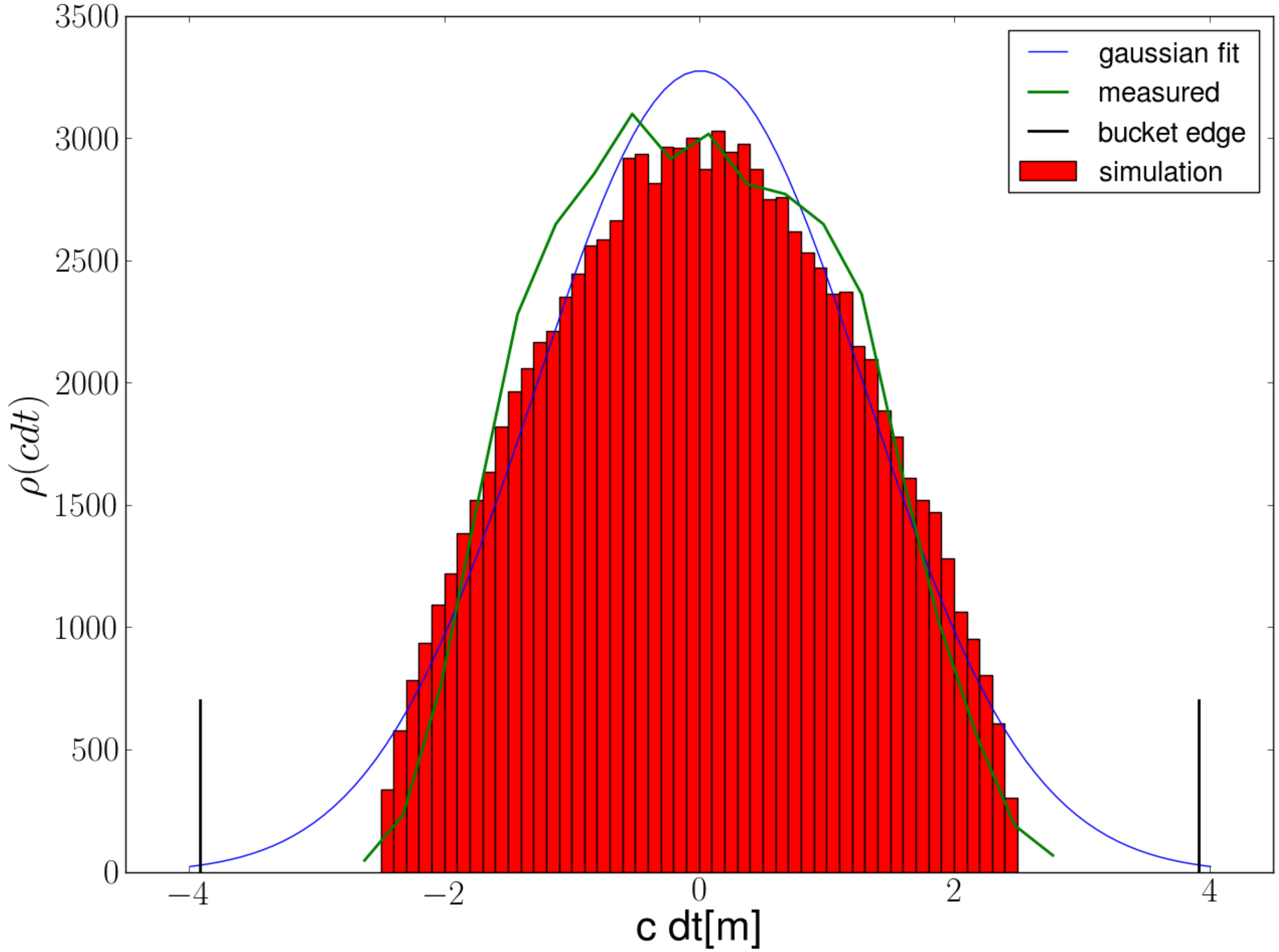


Gaussian beams?
What is the meaning of the rms given by the measurements?
Is it the rms of the distribution or it is the sigma of the Gaussian fit?

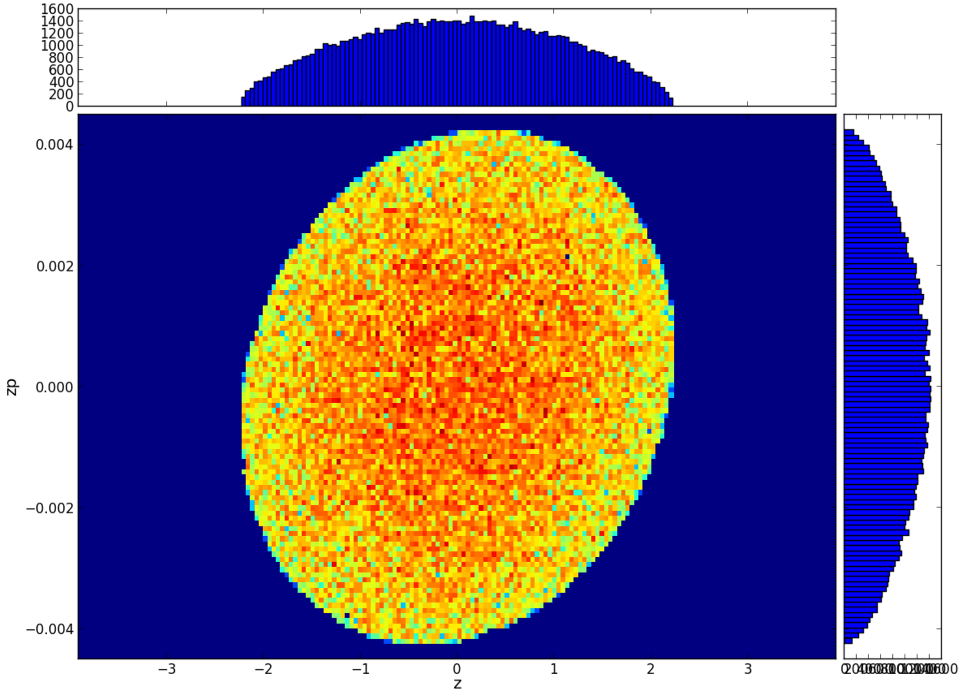
Cutting the tails:

$$\rho(z, z_p) = \rho(J, \Phi) = \begin{cases} e^{-J/\epsilon} & J \leqslant J_c \\ 0 & J > J_c \end{cases}$$

$$\rho(z) = e^{-z^2/2\sigma^2} \, erf\left(\sqrt{J_c - z^2}\right)$$

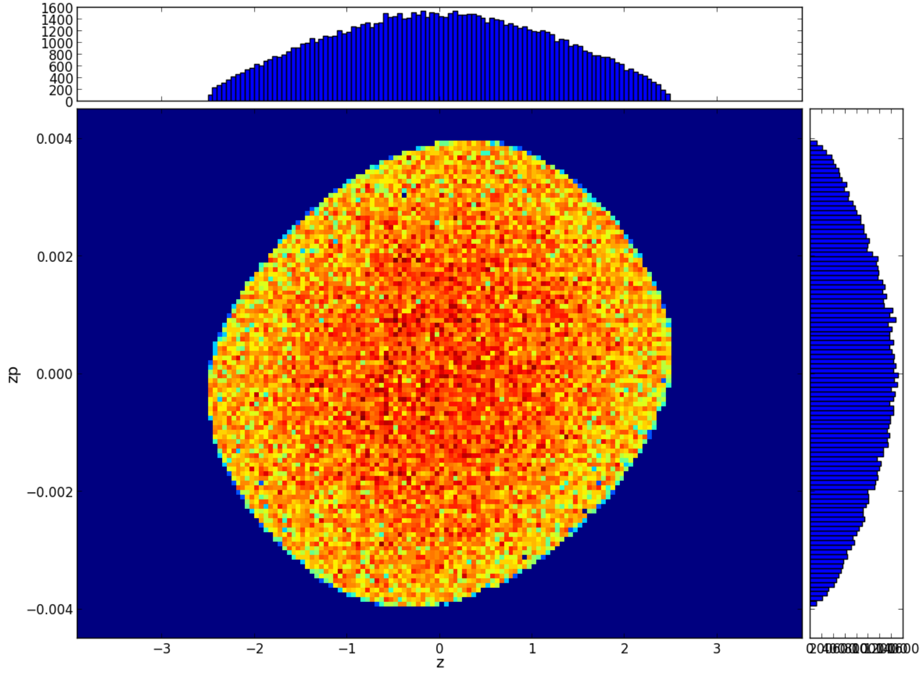


Gaussian fit zrms=1.2 m
zrms=0.83 m



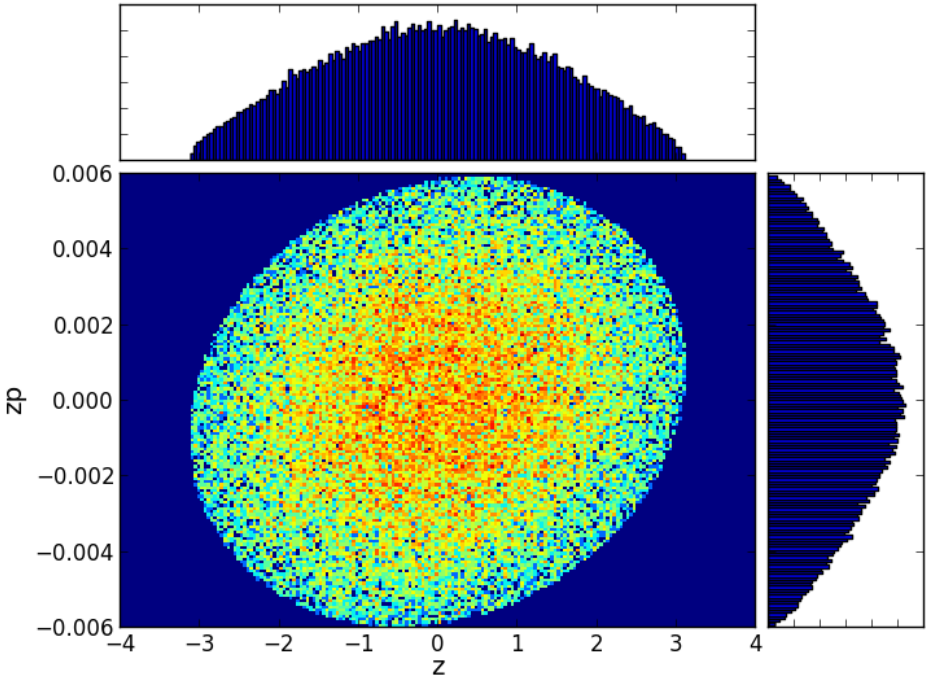
1 order match

δp/p larger

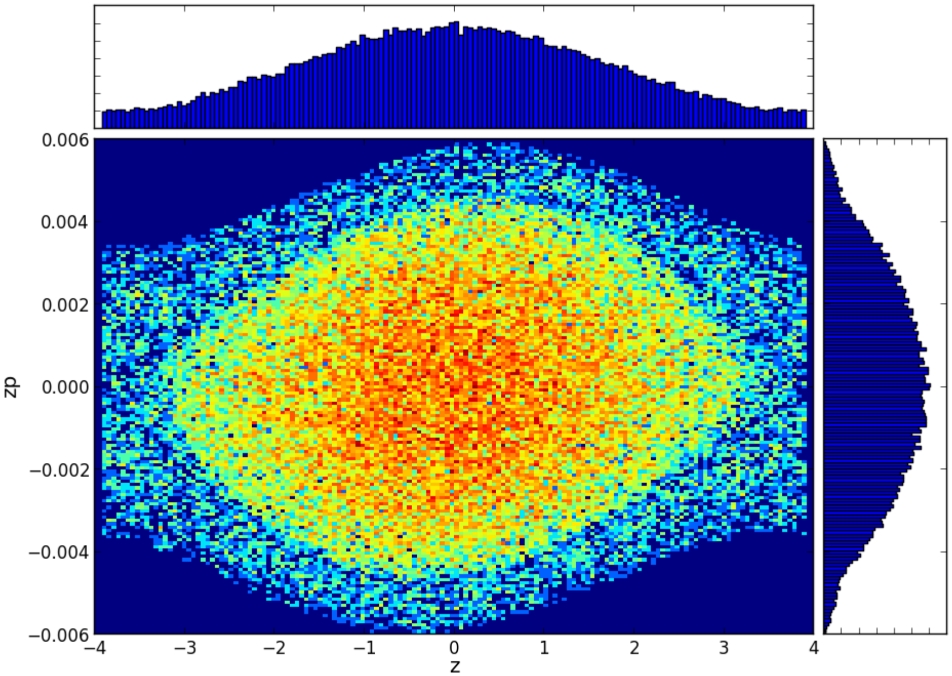


7 order match

1 order match

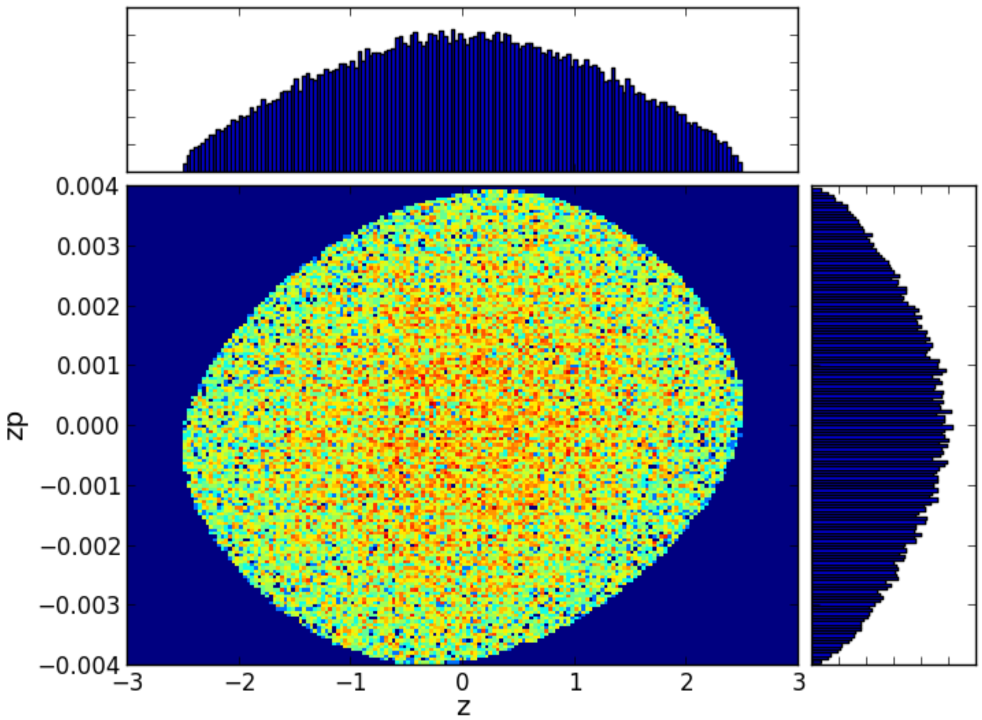


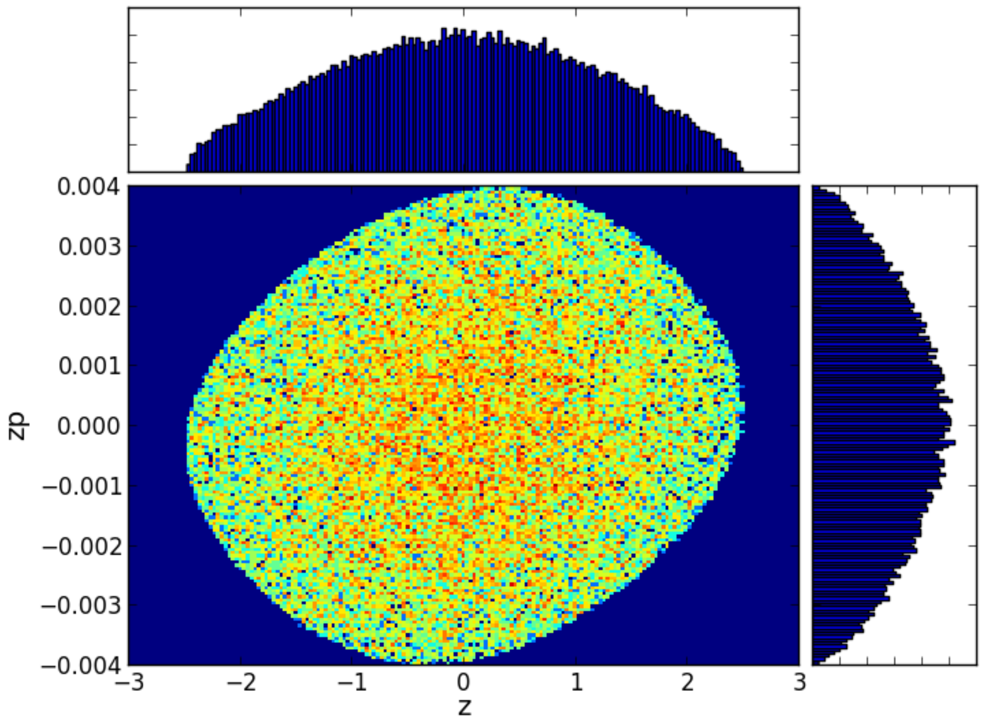
Input distribution



Turn 500

7 order match for the ideal lattice

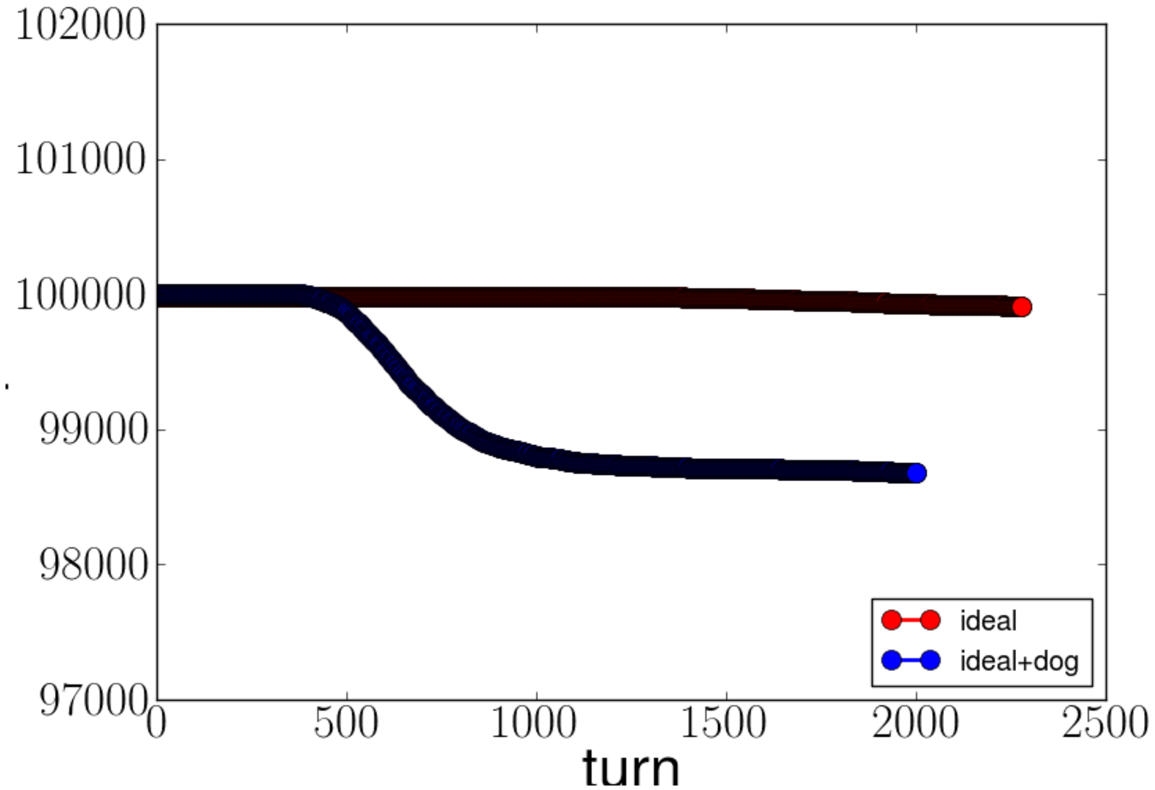




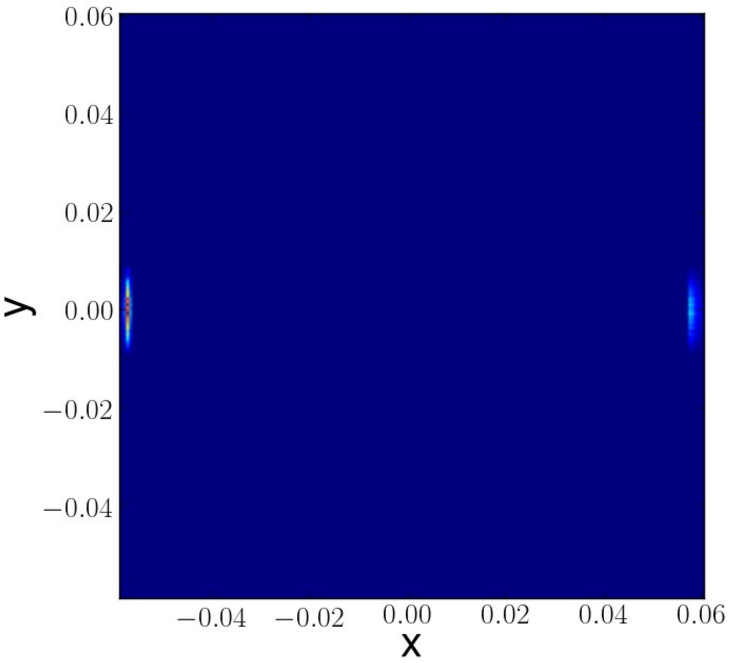
Input distribution

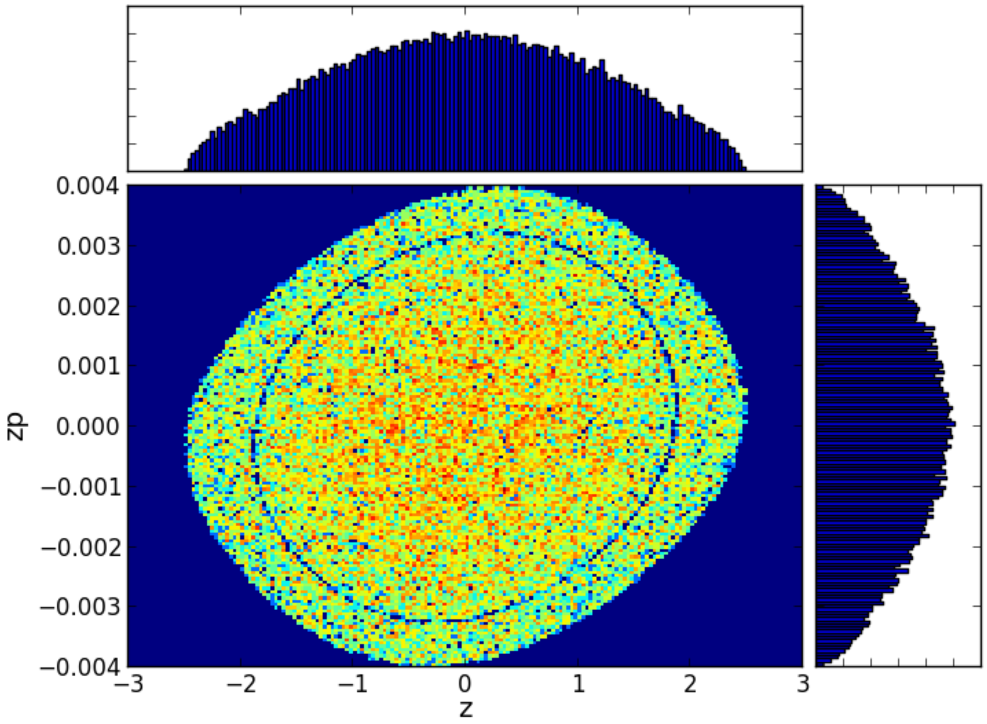
Turn 1000

Comparison ideal lattice with ideal+dogs lattice



ideal+dog loss





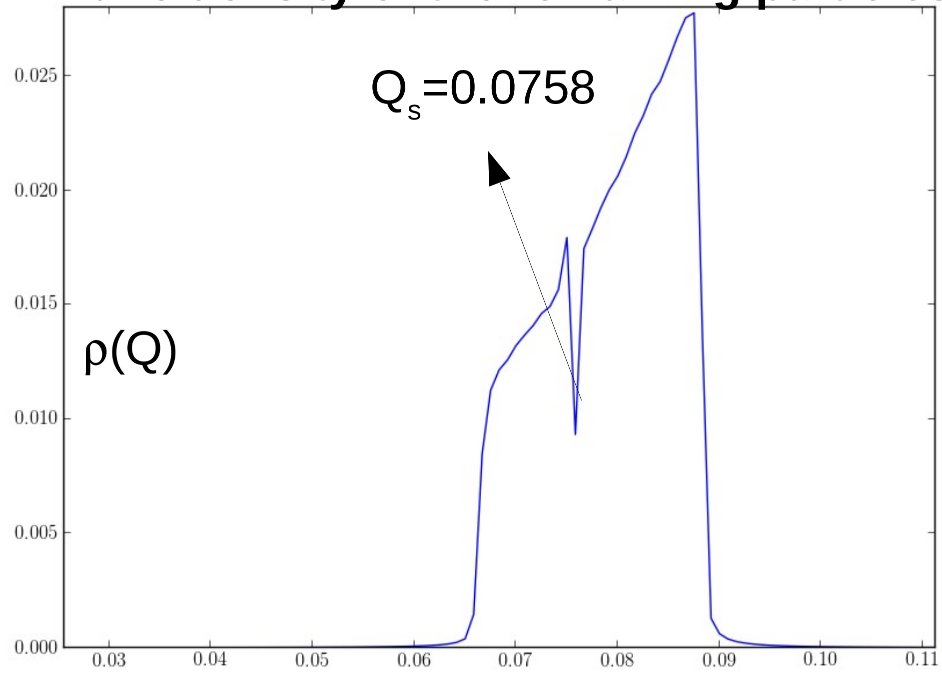
Turn 1900

Q_x=0.7730

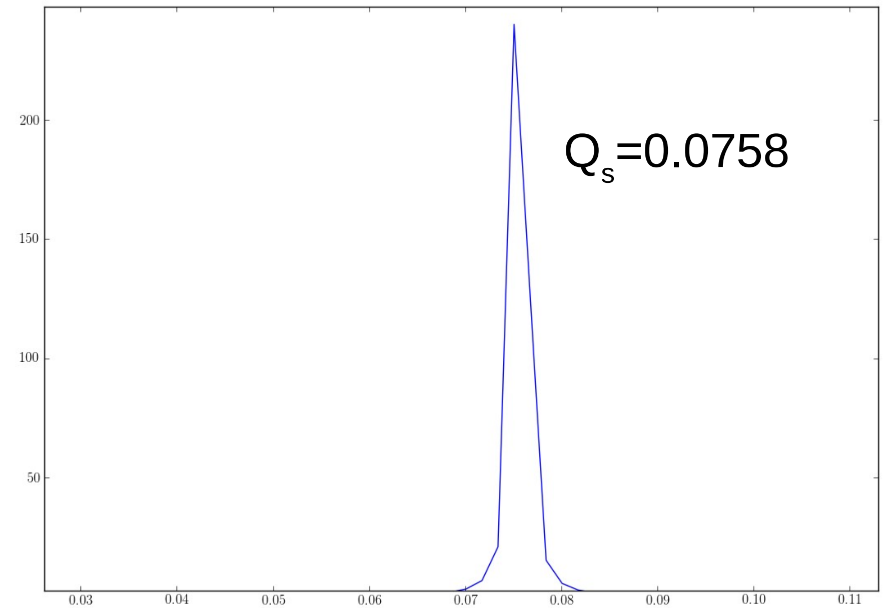
Resonance:

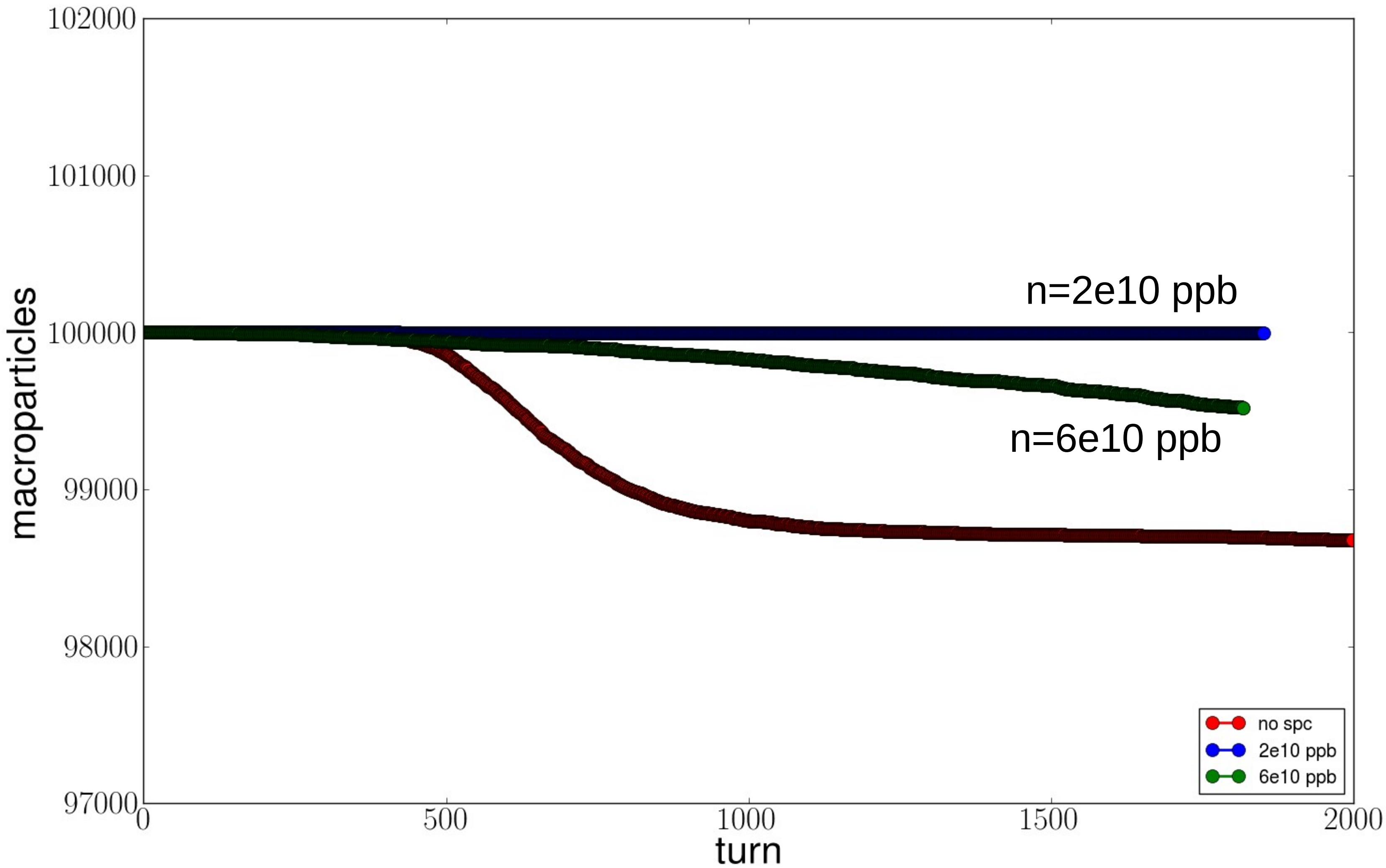
$3Q_s(J_z)+Q_x=1$

Tune density of the remaining particles



Tune density of the lost particles

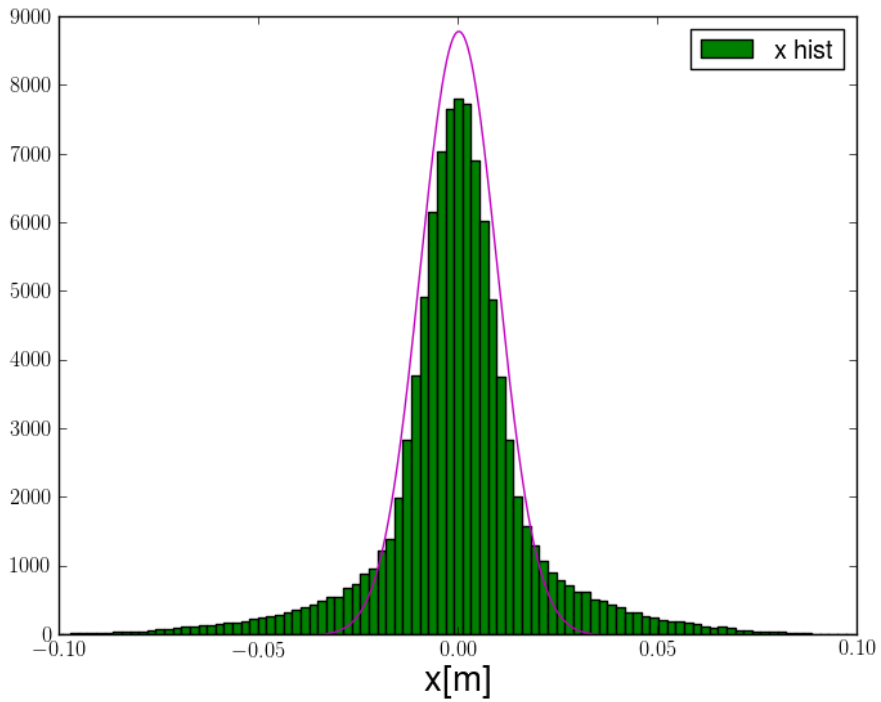




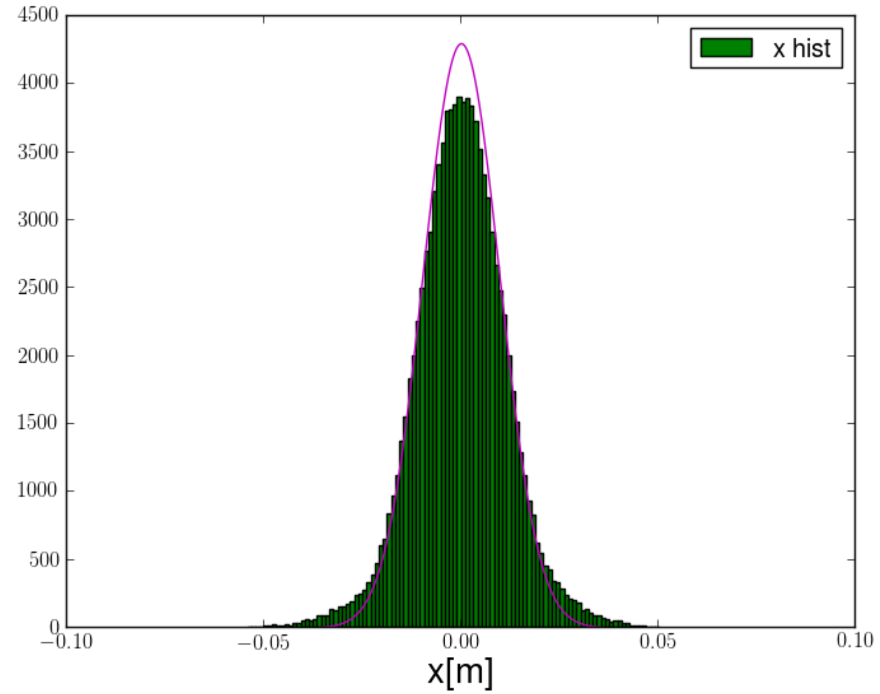
The resonance $3Q_s+Q_x=1$ has no effect when spc is present

HEP lattice

7 order beam matching not possible for the desired longitudinal distribution



Skew elements off



Horizontal profile, 5 order matching

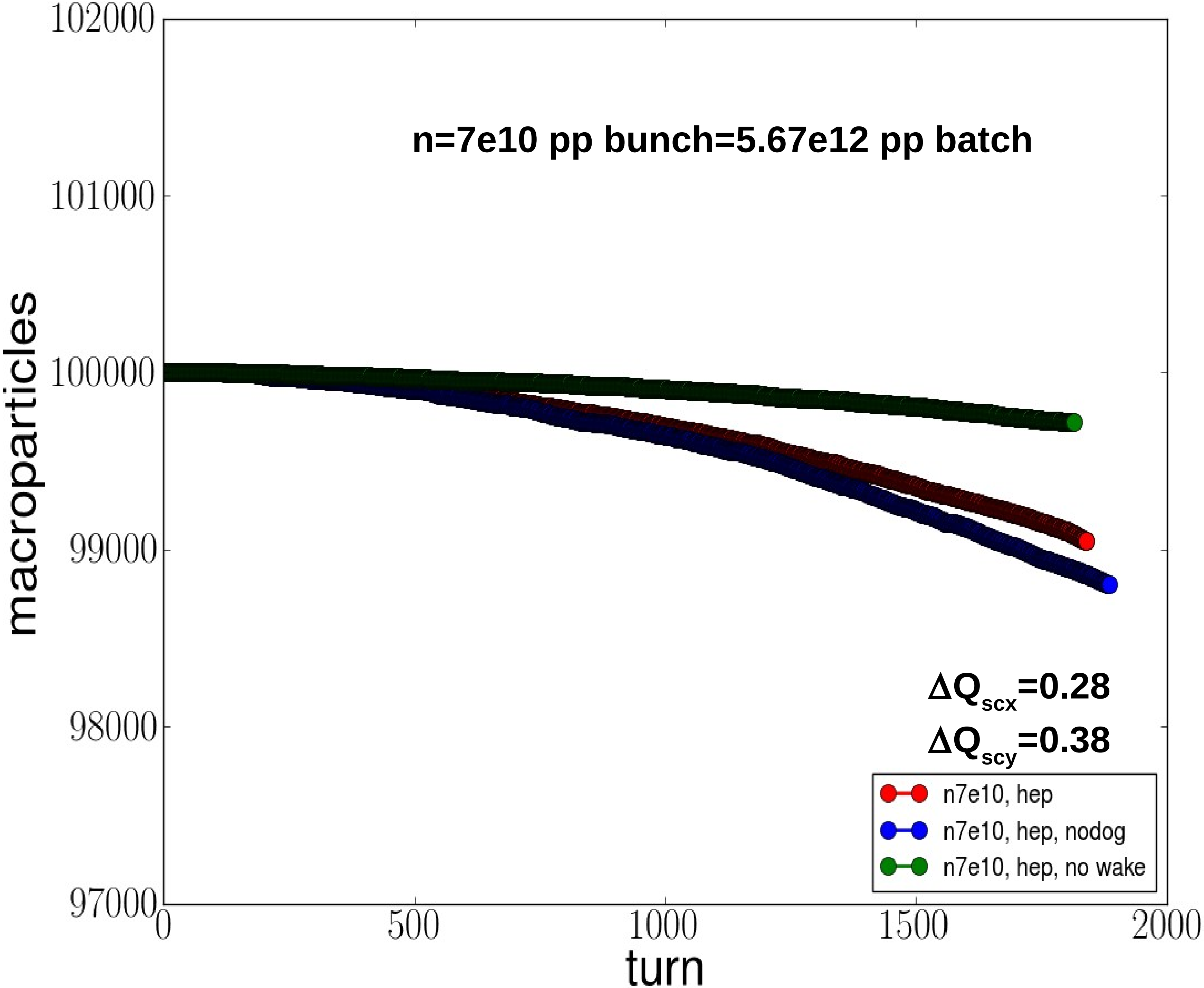
Reason for failure: resonance Q_x-Q_s=0.6666 ($3Q_x$-$3Q_s$=n) for the particles with large z

- **Longitudinal-horizontal coupling resonances important for the non interacting beam dynamics**

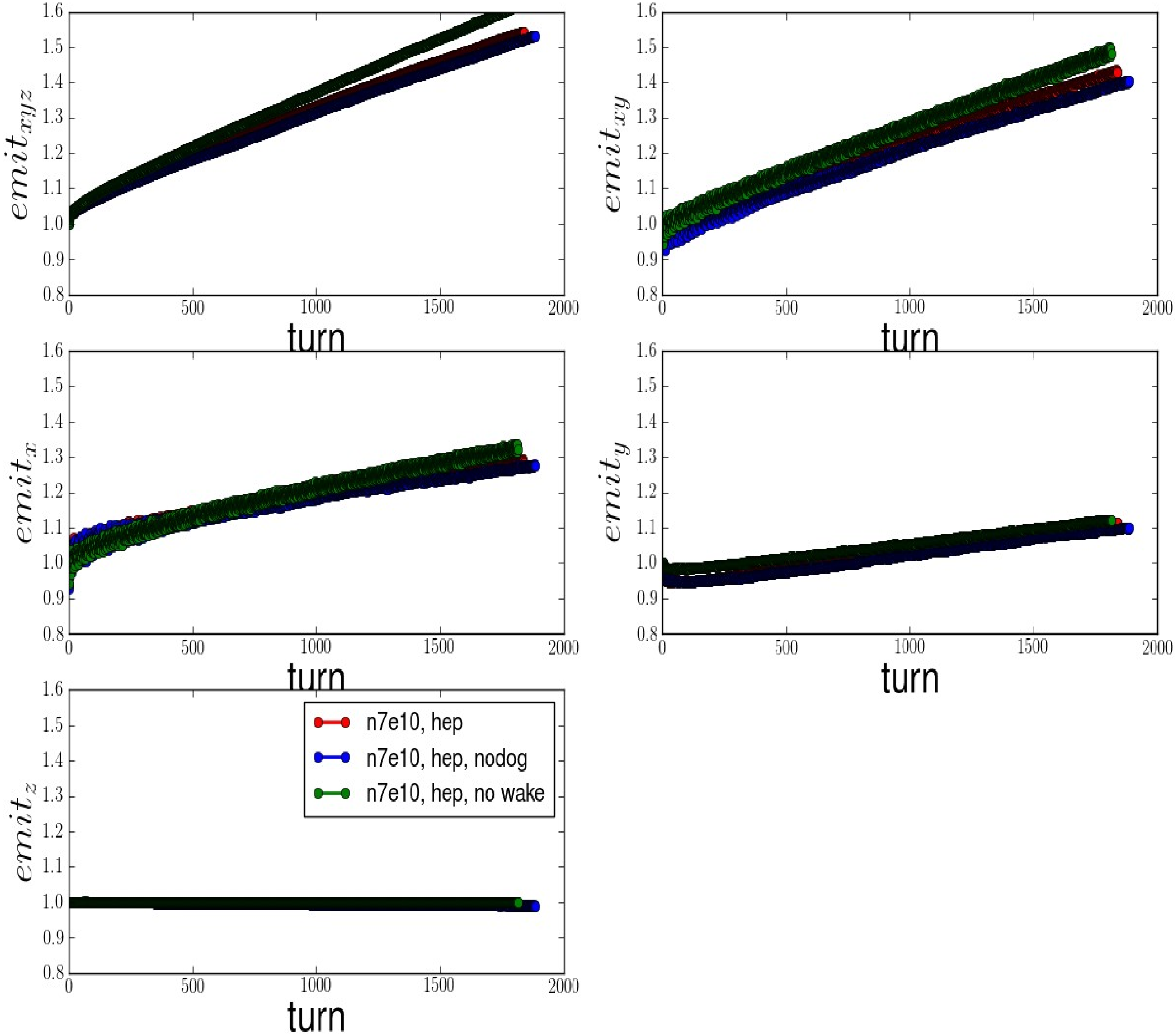
- **Due to the resonances is not always possible to find a match beam**

- **Since these resonances (probably) are not so important when the space charge effects are considered, I proceed by using as input the ideal lattice match beam**

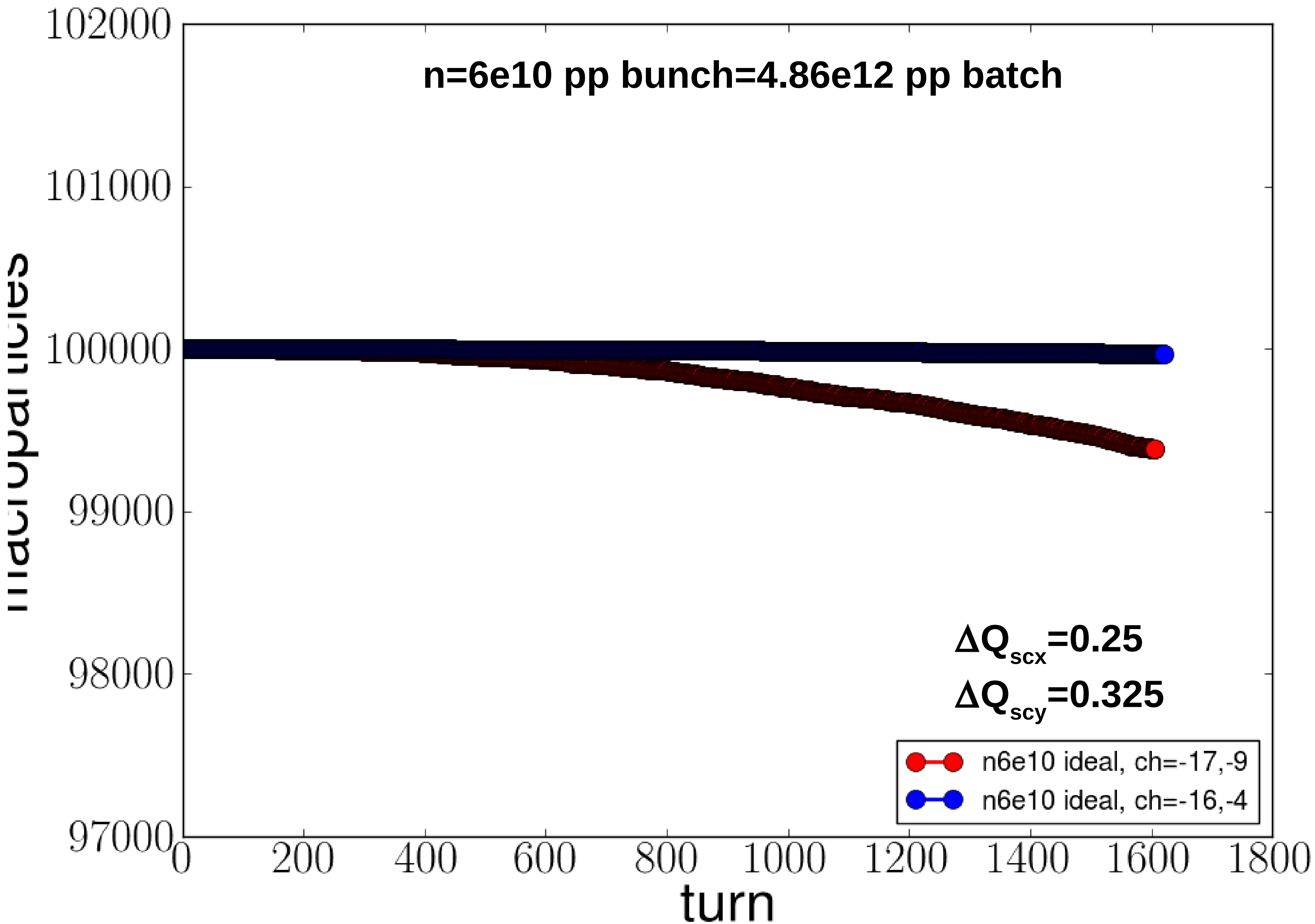
- **Should the skew quads and the skew sextupoles be turned on in the simulations?**

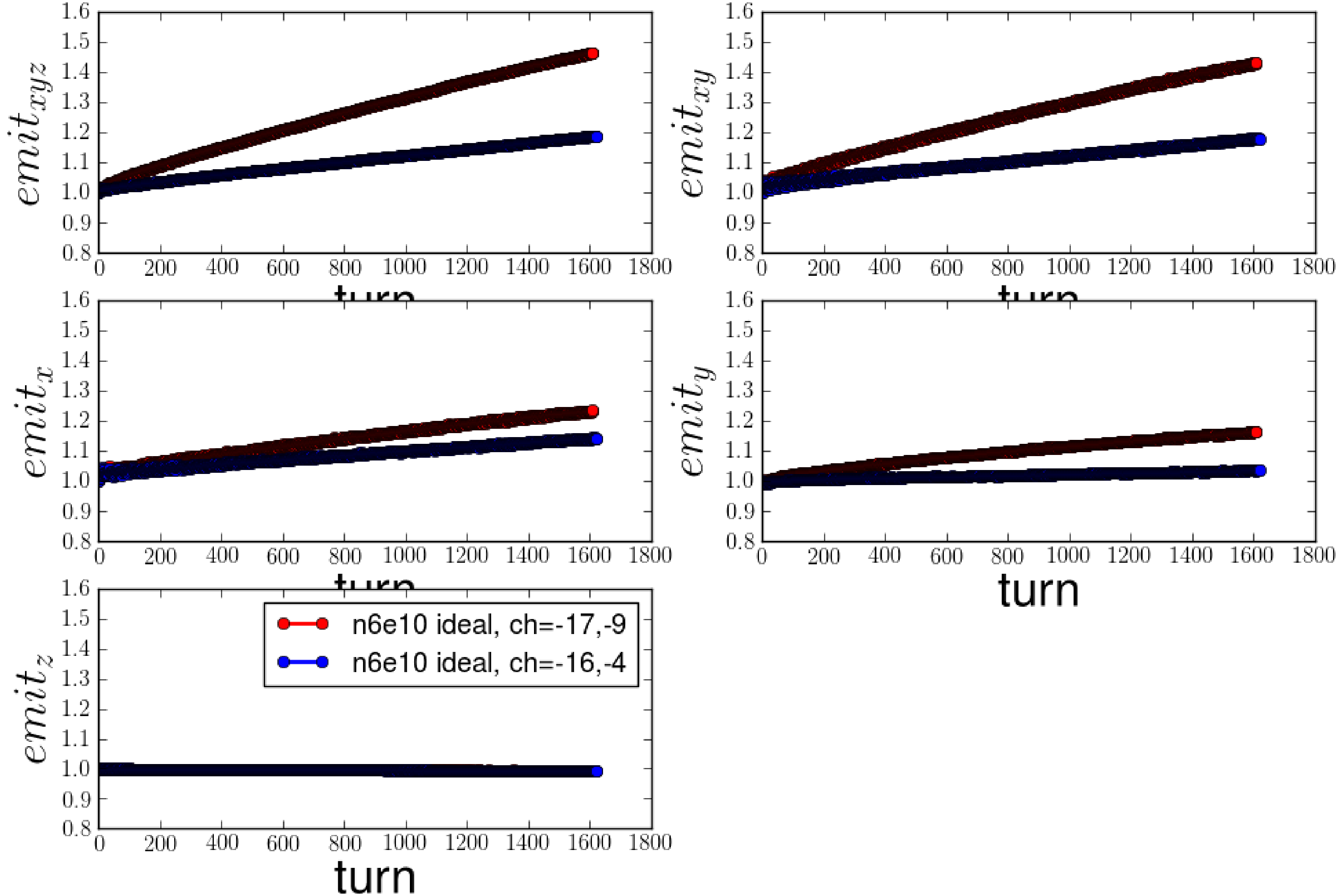


n=7e10 pp bunch=5.67e12 pp batch
macroparticles
turn
102000
101000
100000
99000
98000
97000
0
500
1000
1500
2000
ΔQ_scx=0.28
ΔQ_scy=0.38
n7e10, hep
n7e10, hep, nodog
n7e10, hep, no wake

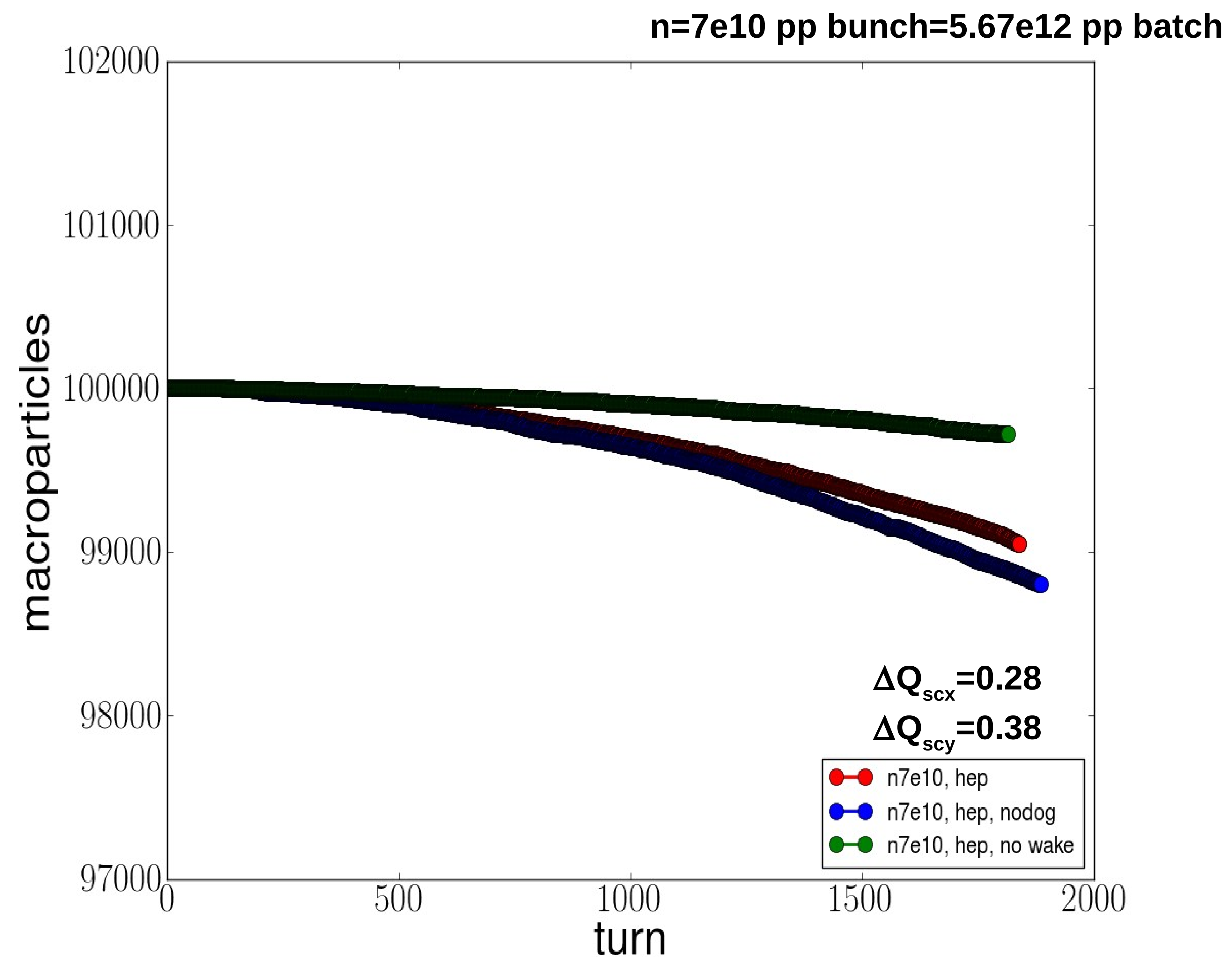

$emit_{xyz}$
$emit_{xy}$
$emit_x$
$emit_y$
$emit_z$
turn
n7e10, hep
n7e10, hep, nodog
n7e10, hep, no wake

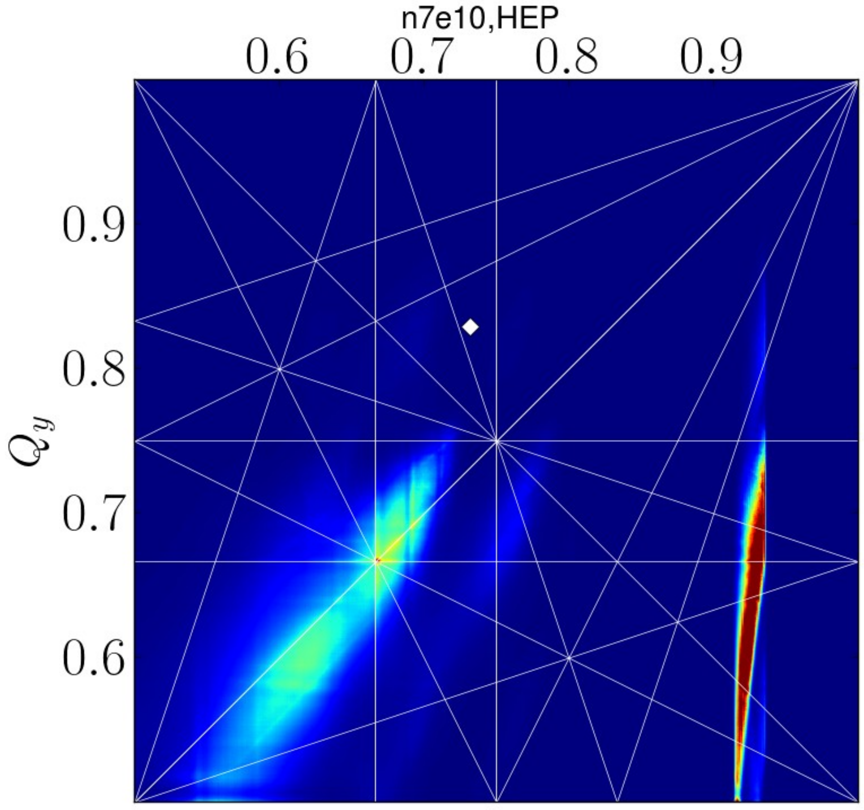
Larger chromaticity , larger beam loss

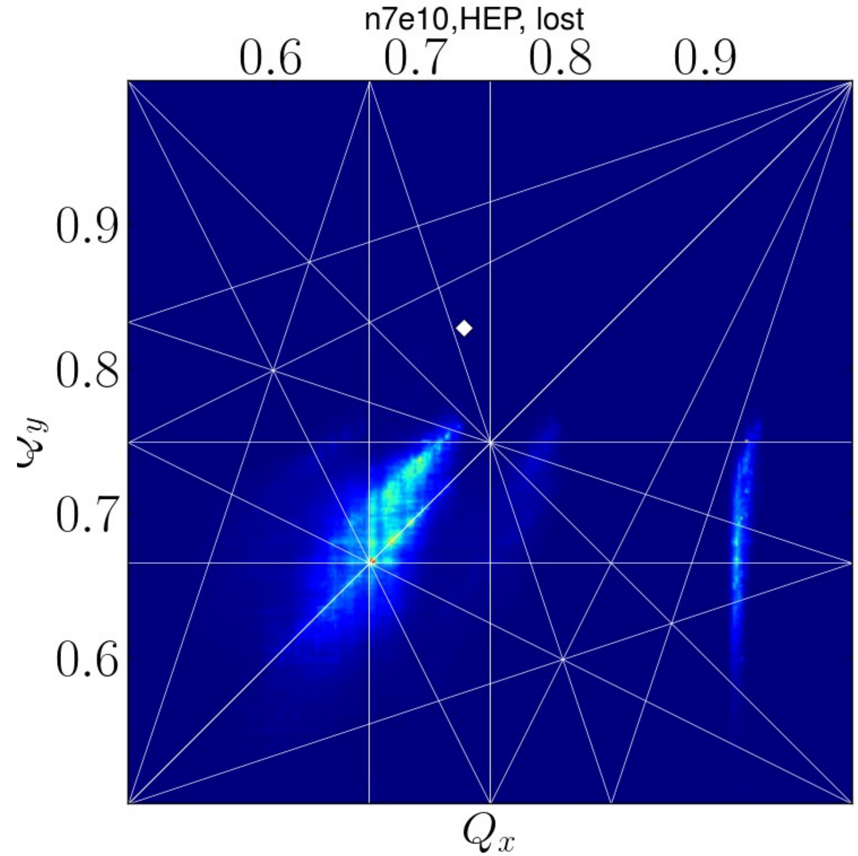


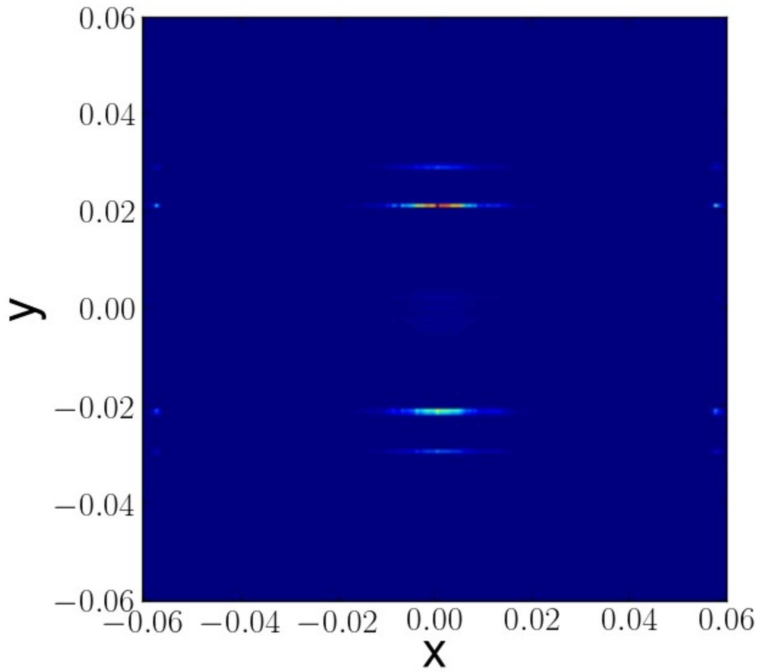


emit_xyz
emit_xy
emit_x
emit_y
emit_z
turn
n6e10 ideal, ch=-17,-9
n6e10 ideal, ch=-16,-4

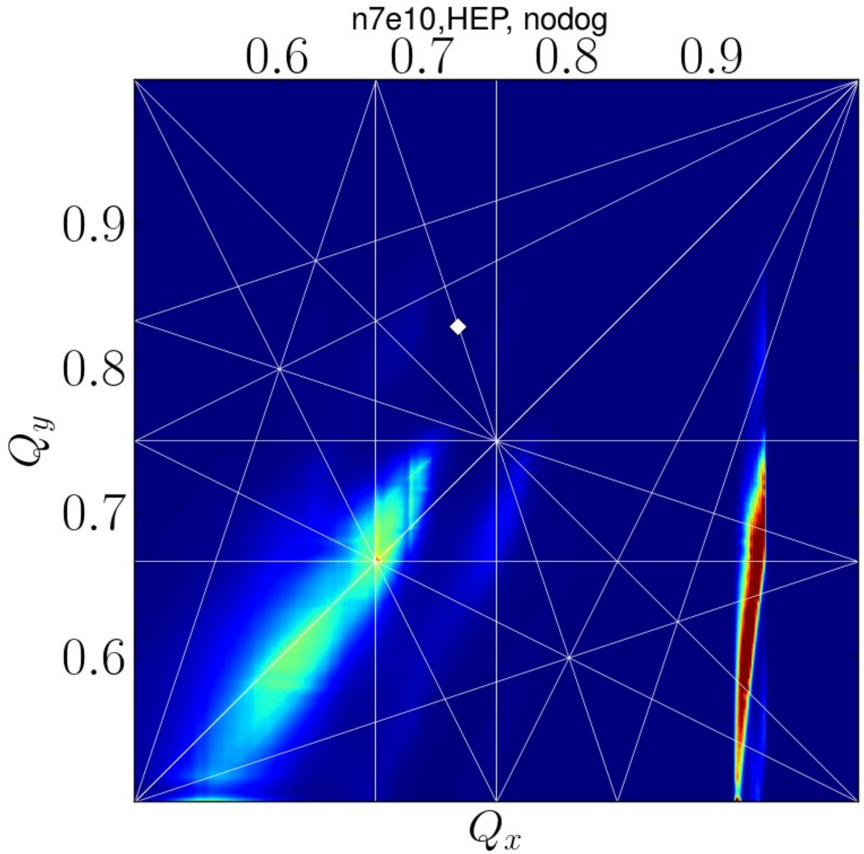

n=7e10 pp bunch=5.67e12 pp batch
macroparticles
turn
102000
101000
100000
99000
98000
97000
0
500
1000
1500
2000
ΔQscx=0.28
ΔQscy=0.38
n7e10, hep
n7e10, hep, nodog
n7e10, hep, no wake

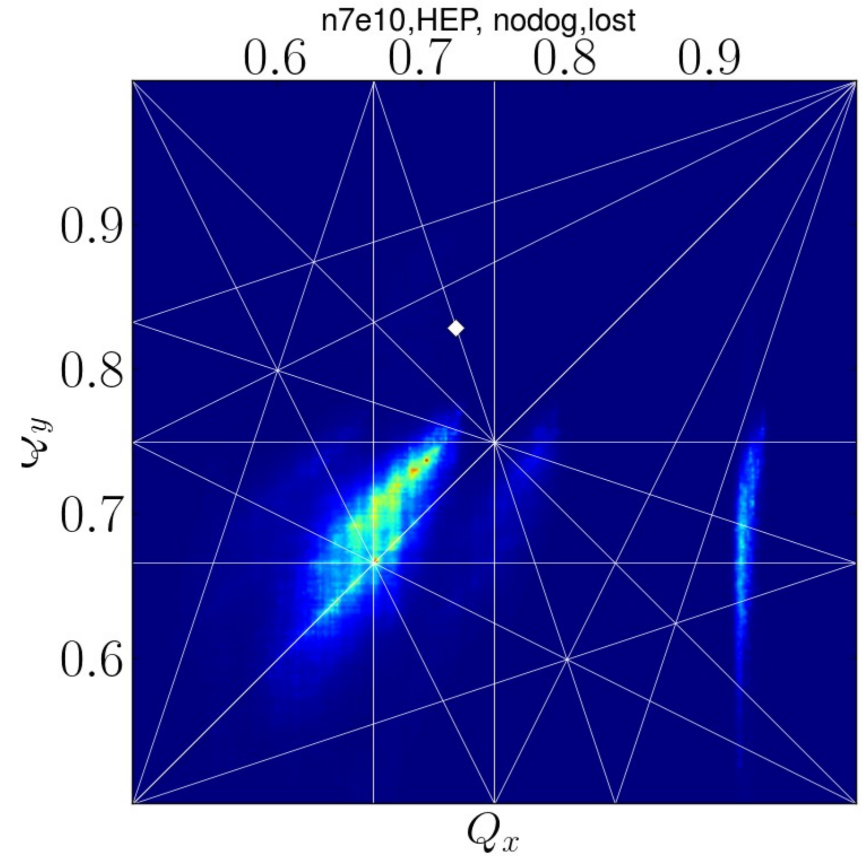


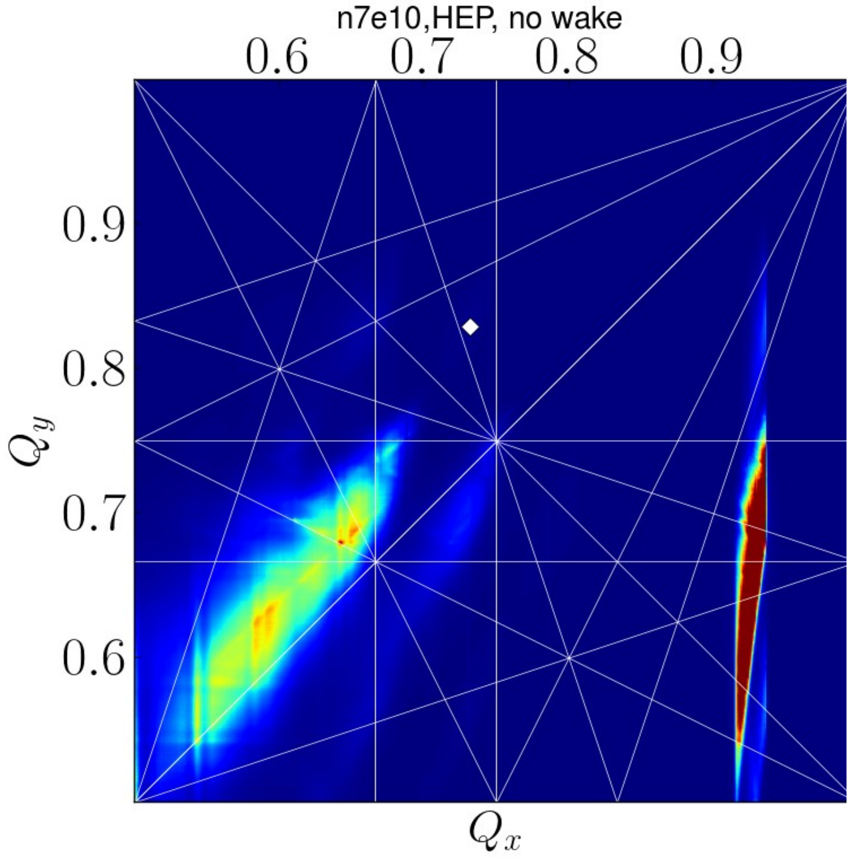




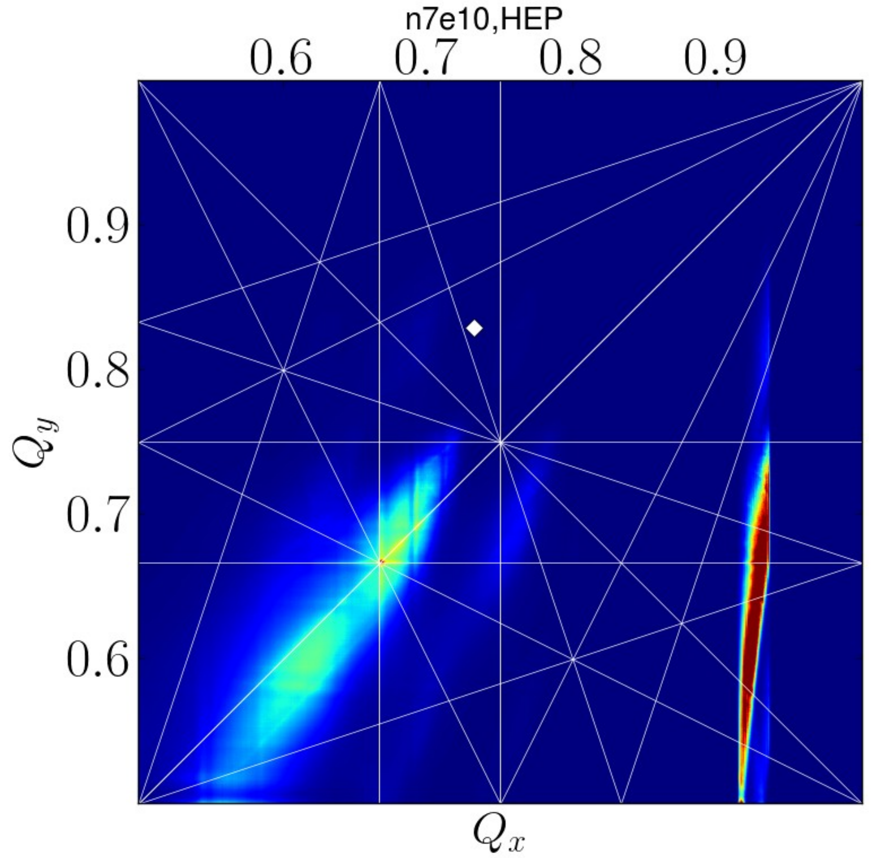
- **Enhanced spectral weight at Q_x=Q_y=0.6666**
- **Loss at vertical apertures**


n7e10,HEP, nodog
0.6
0.7
0.8
0.9
0.9
0.8
0.7
0.6
Q_y
Q_x


n7e10,HEP, nodog,lost
0.6
0.7
0.8
0.9
0.9
0.8
0.7
0.6
Q_y
Q_x

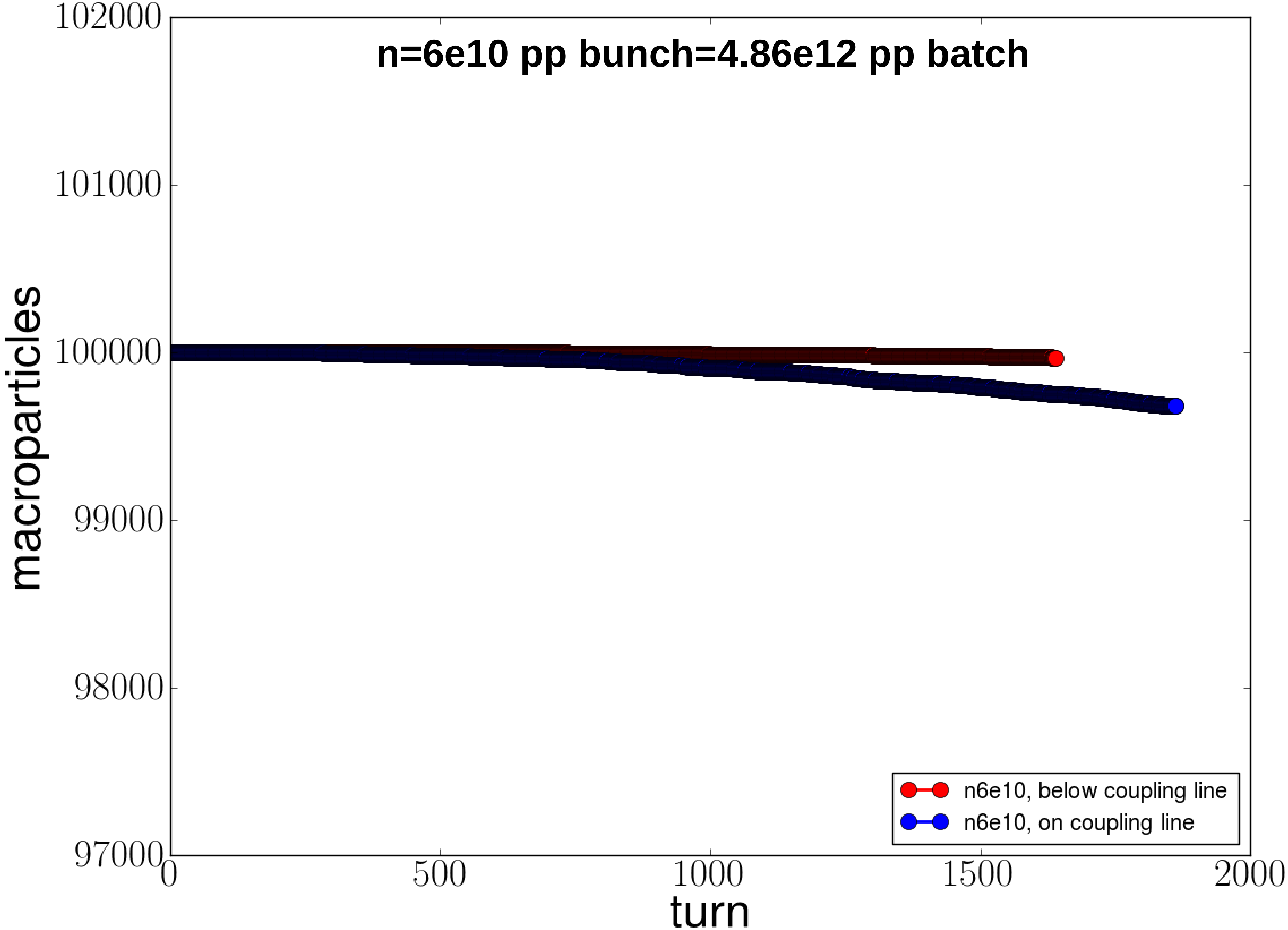


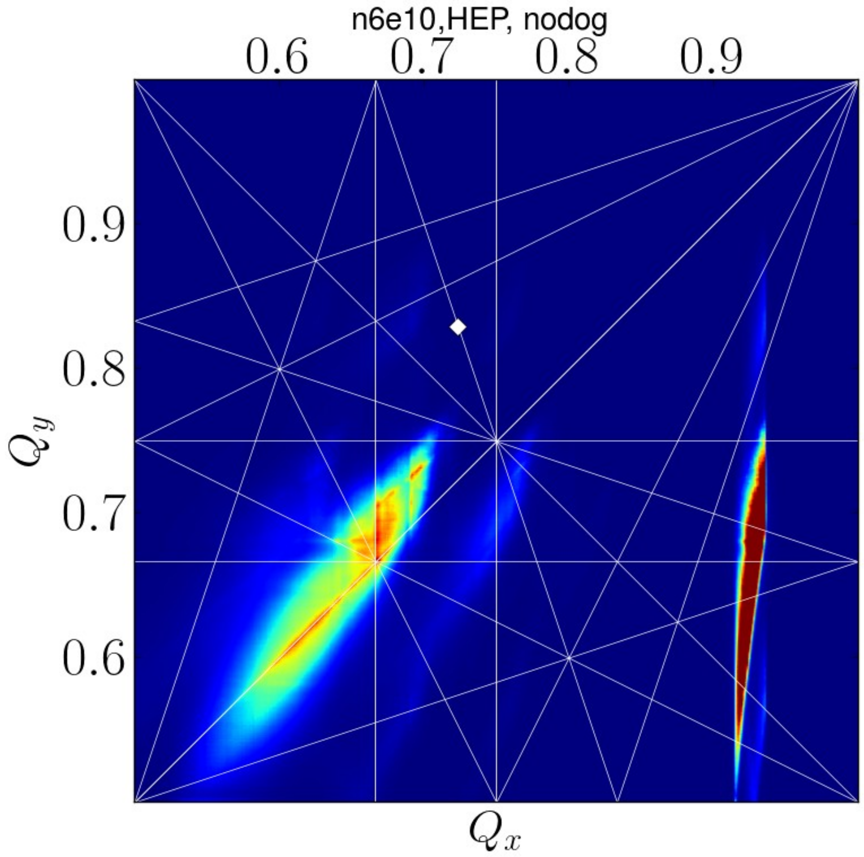
Smaller loss



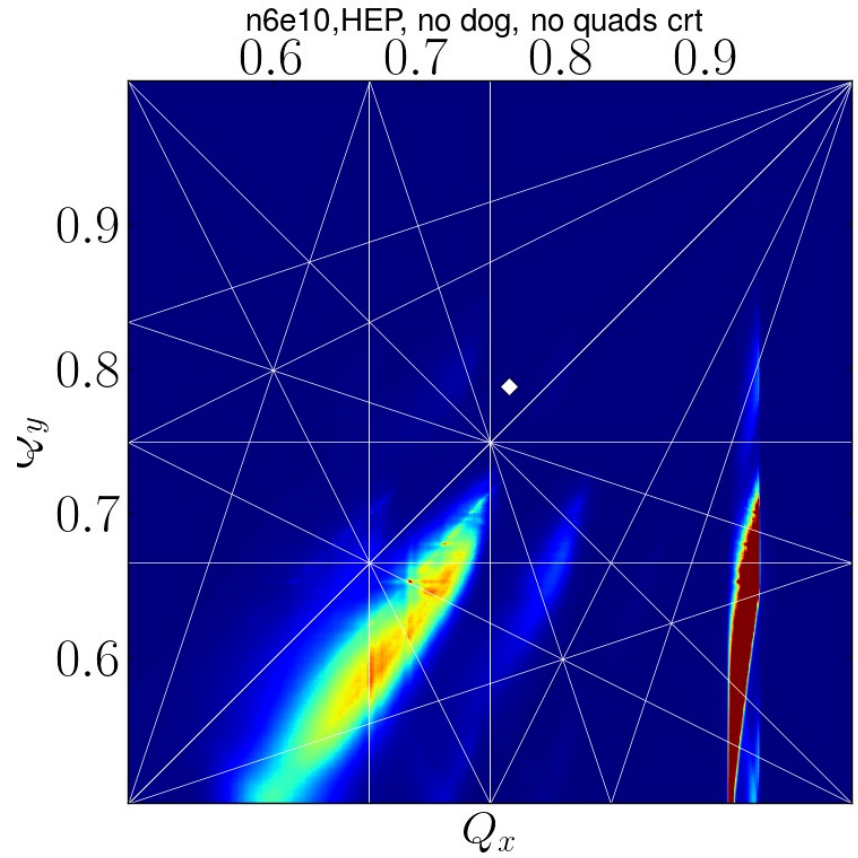
Larger loss

Tunes on the coupling line, Q_x=Q_y, favors loss?


n=6e10 pp bunch=4.86e12 pp batch
macroparticles
turn
102000
101000
100000
99000
98000
97000
0
500
1000
1500
2000
n6e10, below coupling line
n6e10, on coupling line



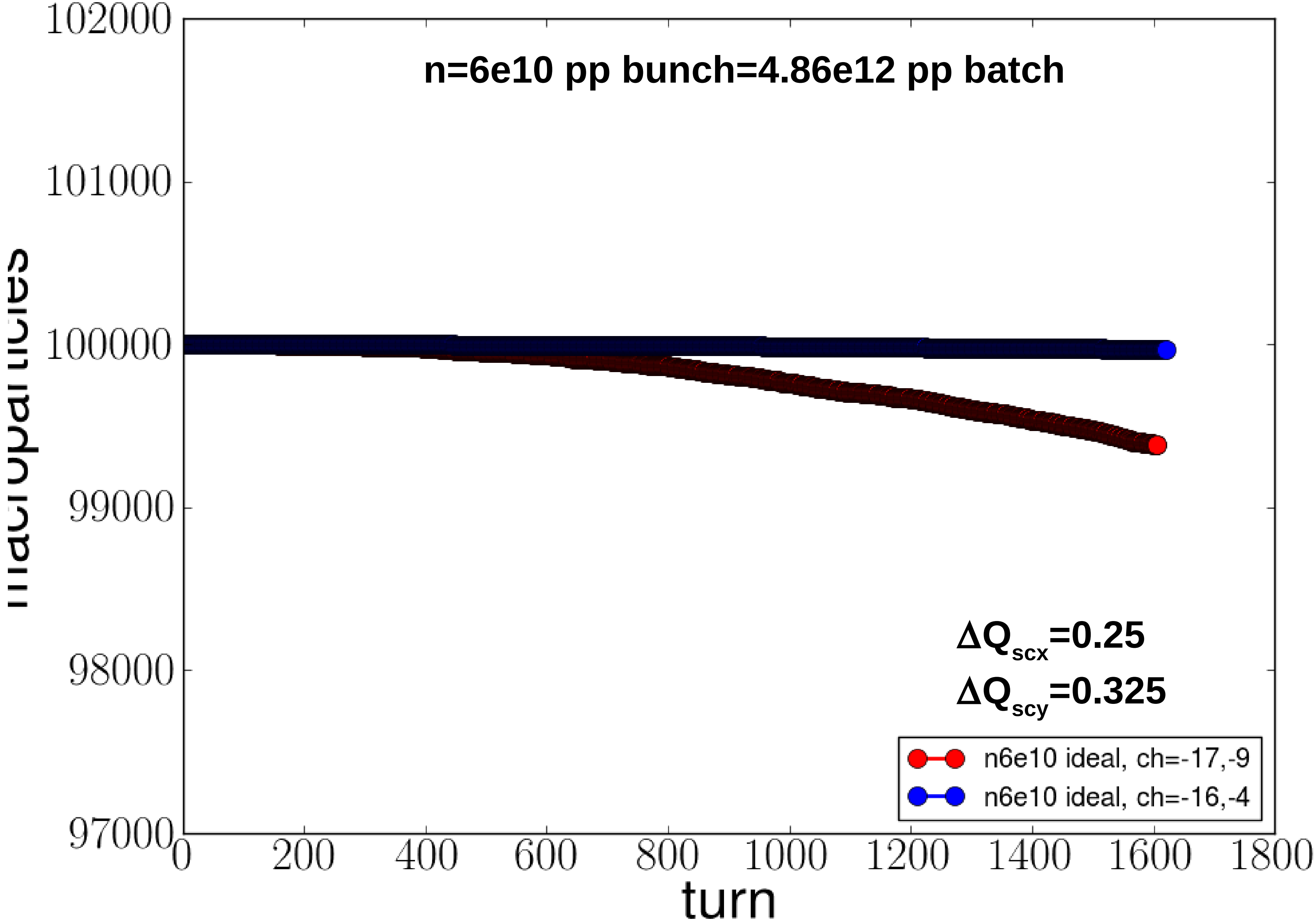
larger loss

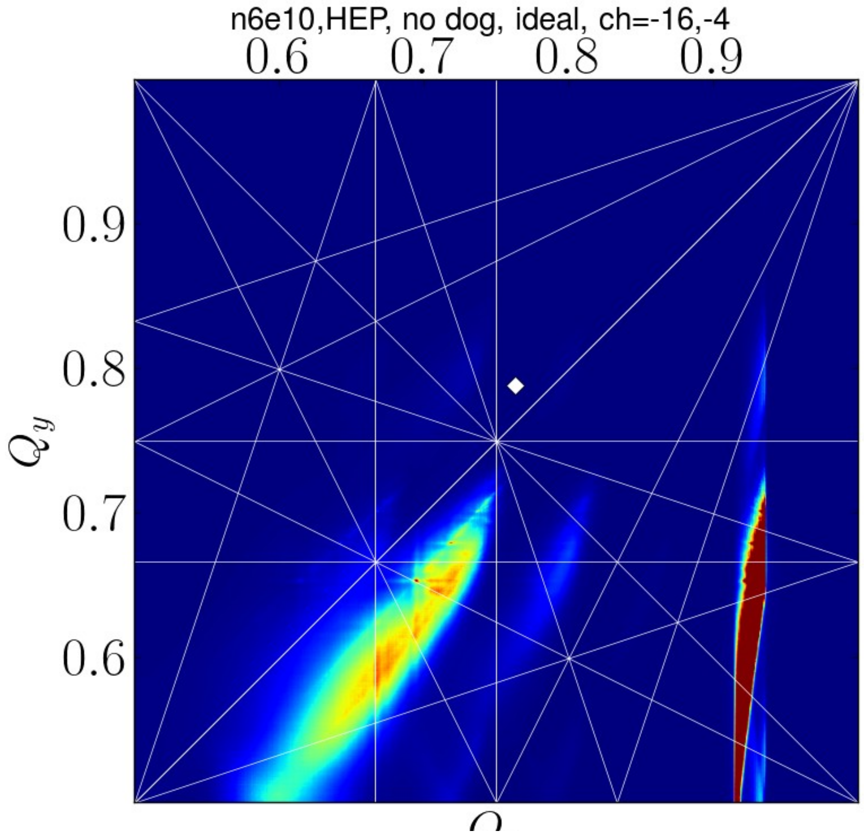


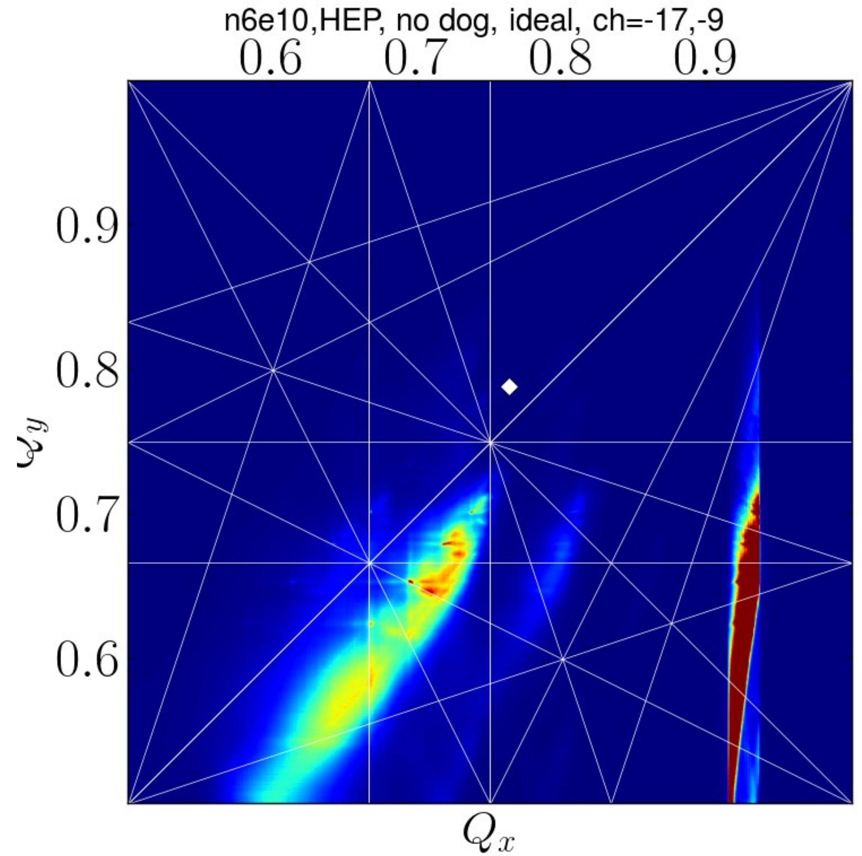
smaller loss

Tunes on the coupling line, Q_x=Q_y, favors loss?

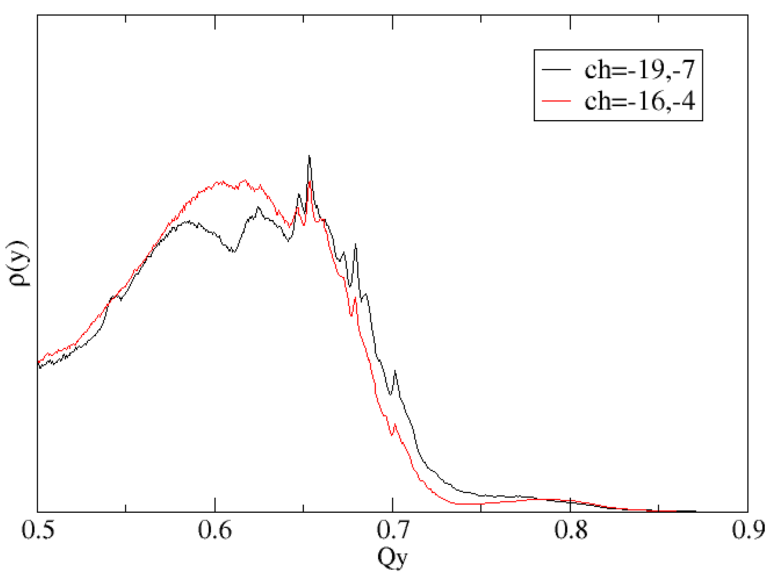
Larger chromaticity , larger beam loss

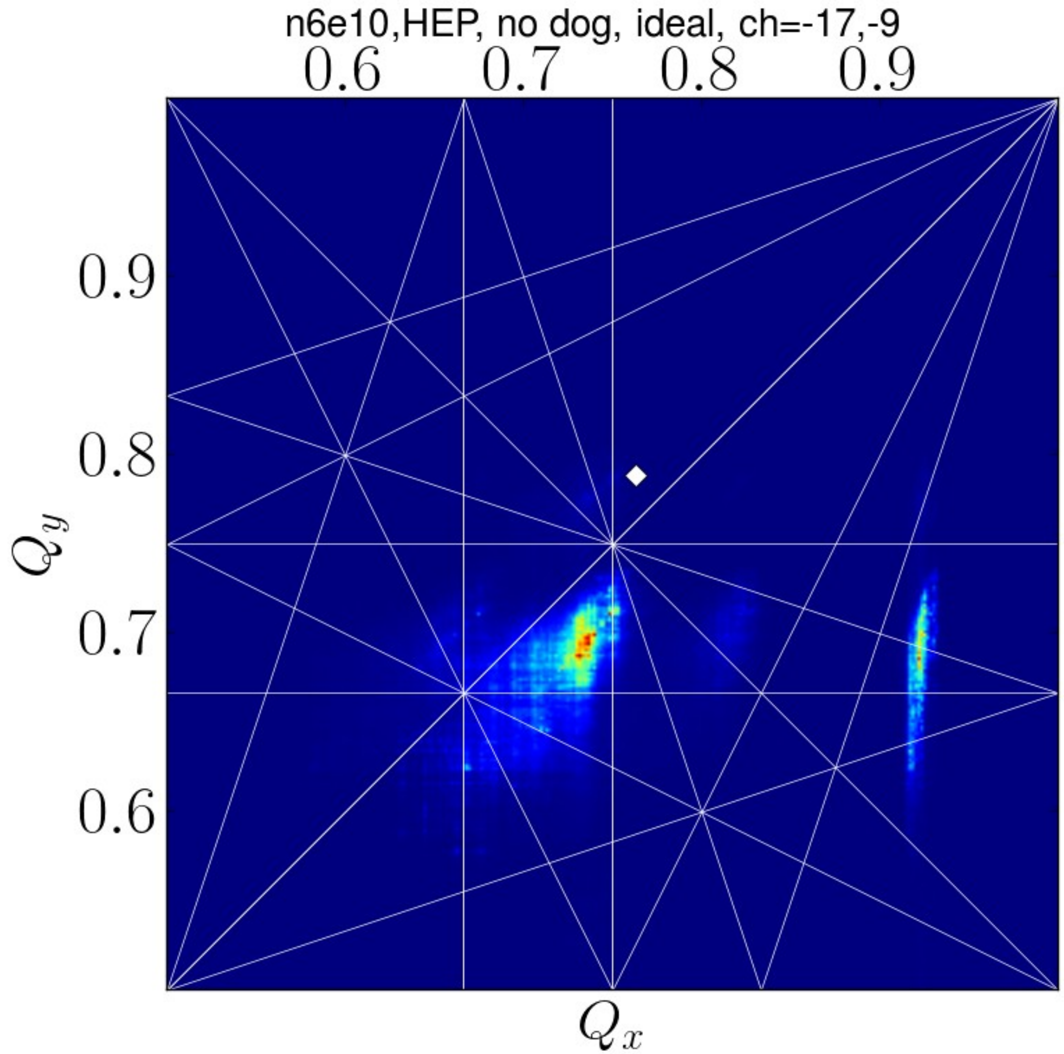



n6e10,HEP, no dog, ideal, ch=-16,-4
0.6
0.7
0.8
0.9
Q_y


n6e10,HEP, no dog, ideal, ch=-17,-9
0.6
0.7
0.8
0.9
Q_y
Q_x

Larger loss


ch=-19,-7
ch=-16,-4
ρ(y)
0.5
0.6
0.7
0.8
0.9
Qy


n6e10,HEP, no dog, ideal, ch=-17,-9
0.6
0.7
0.8
0.9
0.9
0.8
0.7
0.6
Q_y
Q_x

- **Dog magnets have a small effect on beam loss. They seem to decrease the loss.**
- **Chromaticity has a large influence on beam loss.**
- **The beam loss is larger wen the tune footprint is on the coupling resonance line Q_x=Q_y**
- **No evidence that half integer resonance is important for beam loss**
- **Is the third integer resonance line Q_y=0.666, or is the multiple resonance point Q_x=Q_y=0.666 relevant for beam loss?**